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Botany

NEWSLETTER
of the
Hawaiian Botanical Society

c/o DEPARTMENT OF BOTANY
UNIVERSITY OF HAWAII
HONOLULU 14, HAWAII

Volume II
Number 4
April 1963

COTTON IN THE HAWAIIAN ISLANDS[1]

S. G. Stephens[2]

The genus Gossypium is represented in the Hawaiian Islands by three species---G. barbadense L., G. hirsutum L., and G. tomentosum Nutt. The latter is endemic to the islands. These all belong to the so-called "New World" group of cottons with 26 pairs of chromosomes. They intercross readily and produce fully fertile hybrids. Taxonomically they are rather easily distinguishable, at least in living material, by the form of the staminal column and the nature of the seed fibers.

Staminal column: The basic arrangement of stamens in cotton flowers, as seen in transverse sections of young flower buds, is in five double longitudinal rows surrounding the pistil. This basic arrangement is modified by fusions---in characteristic patterns in the different species. In G. barbadense the bases of the staminal filaments are fused into a long tube, and the "free ends" bearing the anthers are relatively short. In G. hirsutum, only the lower filaments are regularly fused, so that the anthers are borne on short filaments toward the base of the column, with longer filaments toward the apex. In G. tomentosum the filaments are very long and fused rather regularly in pairs to form bifid "units."

Seed fibers: In both G. barbadense and G. hirsutum the seed fibers are of two distinct kinds---a short undercoat of strongly thickened fibers (fuzz or linters) and a layer of long convoluted "ribbon-like" fibers (lint) which pull readily from the seed without breakage. Mutant forms, in which the fuzz layer is missing, have often been preserved in culture (e.g., the Sea Island cottons). In G. tomentosum the seed fibers are present as a single layer. They are short, weakly convoluted, and strongly adherent to the seed coat from which they cannot be pulled readily. Wrenching the fibers from the seed causes irregular breakage: such fibers would be useless for spinning.

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[1] In part, a discussion presented at the March 3, 1963, meeting of the Hawaiian Botanical Society.

[2] Visiting Professor of Genetics, University of Hawaii (Spring Semester 1963); William Neal Reynolds Professor of Genetics, North Carolina State College.

In other Pacific Islands, *barbadense* and *hirsutum* are found both as relics of earlier cultivation, as commensal forms in house-yards, or occasional escapes in waste places, and in a truly wild state, as components of the natural vegetation undisturbed by man. In the Hawaiian group they are only found as commensal forms, which in all probability are relics of former attempted cultivations in the 19th and early 20th centuries. The Marin Journal (Jones, 1937) has an entry for April 22, 1812, indicating that cotton was sown in Queriji (Kalihi ?) on that date. Later introductions included Brazilian cotton (kidney-seeded types of *G. barbadense*), Caravonica (a hybrid derived by crossing annual Sea Island cotton with perennial kidney types), annual Sea Islands (*G. barbadense*) from the Carolinas and Georgia, and American Uplands (*G. hirsutum*) from various sources including China. Caravonica arrived in Hawaii via Queensland, Australia. The diverse origin of these introductions, and the fact that any mixed planting would undoubtedly lead to continued natural hybridization both between and within species[3], makes any detailed classification of the existing types a rather idle occupation. According to Wilkes (1845) cotton manufacturing in Hawaii was begun under Governor Adams in 1838. In the early twentieth century serious attempts were made to develop a cotton industry (Krause, 1911), but the climatic conditions and the introduction of the pink bollworm (*Pectinophora gossypiella*) were not favorable. Krause (1911) noted that introduced annual types grew as perennials in Hawaii, an observation which explains why the descendants of known introductions of *annual* forms exist today as *perennial* arborescent types. The occurrence of arborescent strongly photoperiodic forms (short-day flowering) with the silky fibers characteristic of Sea Island annual types, and of coarse fibered types with weakly fused seeds (a characteristic found in kidney-type hybrids) suggests that a considerable amount of mongrelization has occurred during the past century. On the whole "*barbadense*-like" types seem to have persisted longer than "*hirsutum*-like types." The former are more often represented in the Herbarium of the Bernice P. Bishop Museum, and they are encountered far more frequently in the field.

The variation found among these commensal forms stands in sharp contrast to the rather uniform appearance of the endemic species, *G. tomentosum*. There is some variation in leaf lobing, and in size and relative dentition of the bracteoles, but in flower and seed characters there is a remarkable consistency. The absence of a leaf nectary---a unique feature among the New World species---is quite uniform, and so is the characteristic tomentum which covers the vegetative parts of the plant. This species is only known in the wild state and apparently has only been collected on the islands of Oahu, Molokai, Maui, Lanai and Kahoolawe. At all events there seem to be no herbarium specimens from Hawaii or Kauai, though Hillebrand (1888) stated that it was present on all the islands. In Oahu today it occurs most commonly on the drier leeward coastal plain from Barber's Point north to the outskirts of Nanakuli; around Maile Point, and again more rarely around the Kaena Point area. It occurs in scattered populations along the roadside, but more extensively as a component of the *Prosopis* scrub on the landward side of the road---rarely on the ocean side. It seems to grow best under partial shade, as an understory with *Sida* spp. under *Prosopis*, and rooting between volcanic boulders on old lava flows. There is a fine stand of it lining the sides of a ravine and sheltered by *Prosopis*, midway between Kahe Point and Piliokahe Beach parks. (Unlike wild forms of *G. hirsutum*, it is apparently not found commonly as a strand plant, on cliffs exposed to salt spray, or around the margins of salt ponds). The Bernice P. Bishop Museum collections indicate that it was once more widely distributed, particularly through the area from Diamond Head to Makapuu Point and around the headland as far as Waimanalo. Today, in this area, only a relic population can be seen west of the Mauka Kai golf course and spilling out along the coastal road in an easterly direction.

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[3] It may be noted that natural hybridization between *G. tomentosum* and the introduced species is occurring at the present time. An introgressed population of *G. barbadense* is flourishing on the roadside near Piliokahe Beach Park in an area where a natural stand of *G. tomentosum* to the south is within a quarter mile of houseyard *G. barbadense* located in the outskirts of Nanakuli.

There is some indication that the flowers of *G. tomentosum* may have been used by the ancient Hawaiians as a source of green dye for their kapa cloth. Bennett (1840) who was a surgeon on a whaling ship states that "a delicate green-yellow dye" obtained "from an infusion of the flowers of the cotton plant" was used for dyeing kapa in Oahu. Elsewhere, in the same narrative he says:

> Several exotic kinds of the cotton-shrub (*pulu* or soft of the natives) grow wild in the plains, and include that rare species, the yellow nankeen cotton (*Gossypium religiosum*) called by the natives *marou*.

Later, Brigham (1911) referred to Bennett's statement and apparently assumed that the latter had confused cotton with *Abutilon incanum*, which also had the Hawaiian name, *máo*, and was also used as a dye. The discrepancy between Bennett's statement and Brigham's interpretation of it is perhaps worthy of further consideration. The following facts appear to be pertinent:---(1) Bennett's use of the (then) accepted Latin nomenclature in identifying the numerous plants he described in his narrative, suggests that he was a competent botanist. A man who could distinguish between *G. vitifolium* (on Pitcairn Island) and *G. religiosum* (on Oahu) would not be likely to confuse either with *Abutilon incanum*. (2) Bennett stated specifically that the *flowers* were used as a source of the dye: according to Brigham it was the *leaves* of *Abutilon* which were used. (3) The Hawaiian name "máo" means "green" and is applied both to *Gossypium tomentosum*[4] and to *Abutilon incanum*. The name is incomprehensible as a description of either plant, but quite understandable if it refers to a common dyeing property. (4) The word "nankeen" was used non-specifically in the 18th and 19th centuries to describe a brown fibered type of cotton. It was applied both to Asiatic and New World cottons and could reasonably have been applied by Bennett to the brown fibered *G. tomentosum*. Bennett's identification of this species as "*G. religiosum*" is consistent with other nomenclature of the same period. For instance, there is preserved in the U. S. National Herbarium a specimen collected in 1845 by the U. S. Exploring Expedition (No. 12935) under the command of Charles Wilkes, which is labelled *G. religiosum*, but whose single layer of adherent seed fibers, absence of leaf nectary, and fine tomentum covering the vegetative parts, identify it unmistakably as *G. tomentosum*. Unfortunately neither the name of the collector nor the location is recorded on the sheet. The expedition visited both Hawaii and Fiji---other cotton specimens in this collection are recorded "from Feejee." (5) It has been known for some time that the flowers of the cotton plant contain pigments, once thought to be of potential importance in the dyeing industry. In the late 19th century, the British chemist William Perkin, made a preliminary investigation of these dyes and identified various flavonoid pigments. Dr. C. R. Parks has recently made a chromatographic survey of these pigments in the genus *Gossypium* as a whole, and has isolated glycosides of three flavonols, gossypetin, quercetin and kampferol. Further, he has shown that the depth of yellow color in the petal is primarily determined by the relative amount of gossypetin present, and that flowers of *G. tomentosum* have larger amounts of this pigment than other species. (This explains the bright buttercup-yellow shade of G. tomentosum flowers as compared with the lemon yellow of G. barbadense and the cream of many G. hirsutum types). Solutions of gossypetin glycosides are bright yellow in color, but separate out greenish crystals when concentrated. Slightly alkaline solutions produce a green dye. Faded flowers of G. tomentosum unlike those of G. hirsutum and G. barbadense, often turn green as they dry out and a greenish yellow dye can be obtained from their crude extract. According to Bennett the "astringent water from the taro patch" was used to mordant the dye---this could have been a matter of P_H adjustment.

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[4] Another Hawaiian name for *G. tomentosum* is "huluhulu," which means "hairy" (Ed.).

It should perhaps be noted that the possible use of G. tomentosum for the purpose indicated above, can have no bearing on the arrival of this species in Hawaii. Since archaeological and related evidence indicates that the Hawaiian Islands were an end point in Polynesian wanderings, and G. tomentosum has not been found elsewhere in the Pacific, it is not likely to have been a Polynesian introduction. The most likely speculation concerning its means of arrival in the Hawaiian Islands would be by oceanic drift from the Central American coast. The seeds of wild forms of G. hirsutum are buoyant enough to float for a long period of time and retain their viability (Stephens, 1958 and unpublished data). According to Guppy (1906) the seeds of G. tomentosum lack this capacity. The fact that the G. tomentosum seeds of today lack buoyancy does not, of course, prove that their ancestors were equally deficient in this respect. Cultivated forms of G. hirsutum also lack buoyancy, and presumably this difference between wild and cultivated forms of the same species has evolved over a relatively short period of time.

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SOCIETY MEETING

DATE: Monday, April 1, 1963, 7:30 p.m.

PLACE: Agee Hall, Experiment Station of the Hawaiian Sugar Planters' Association, 1527 Keeaumoku Street, Honolulu.

SUBJECT: "Soil infertility" (illustrated).

SPEAKER: Dr. Harry F. Clements, Senior Plant Physiologist, Hawaii Agricultural Experiment Station, University of Hawaii, Honolulu.

DUES REMINDER

Members who have not paid their 1963 dues yet are reminded that they should be remitted to the Treasurer as soon as possible. The various expenses of the Society can be met only if the funds are available. The annual dues of two dollars ($2.00), which includes receipt of the Newsletter, should be sent to William M. Bush, Castle & Cooke, Inc., P. O. Box 2990, Honolulu 2, Hawaii. Checks should be made to the Hawaiian Botanical Society.

BOTANICAL NOTES

OTTO DEGENER HONORED: The Linné Medal was awarded to Dr. Otto Degener, Collaborator in Hawaiian Botany, New York Botanical Garden, by the Royal Swedish Academy of Science. The award was made on May 23, 1962, but receipt of the medal was not until last month. It was made in recognition of the work and donations which Degener produced and initiated in favor of the Naturhistoriska Riksmuseet, and the important services which he rendered to the Museum's Department of Botany. Degener resides at Mokuleia Beach, Waialua, Hawaii. (AKC)

HAWAIIAN ACADEMY OF SCIENCE: The Academy meets on Thursday, April 25, and Friday, April 26, at 7:30 p.m. in Agee Hall, H.S.P.A. Experiment Station. The annual banquet will be held on Saturday, April 27, at the Empire Room of the Hawaiian Village Hotel. Further information may be obtained from the Secretary, Dr. Robert Fox, University of Hawaii.

The Hawaiian Junior Academy of Science will hold its second annual meeting on Friday, April 26, at 4:00 p.m. in Agee Hall. High school students will present papers of research results. (AKC)

H.S.P.A.: Mr. Tao-Tze of the Taiwan Sugar Research Station was a recent visitor at the Experiment Station, HSPA. Following a one and one-half year fellowship in the Department of Soils and Nutrition at Berkeley, Mr. Yang spent a week with the staff of the Department of Physiology and Biochemistry. (LGN)

BOTANY SEMINAR: Mr. E. H. Bryan, Jr., Curator of Collections and Manager of the Pacific Scientific Information Center, B. P. Bishop Museum, will present a talk entitled "Stalking Scientists in the South Seas." The seminar will be held on Friday, April 5, 11:00 a.m., Dean Hall 102, University of Hawaii. For further information about the Department of Botany seminars, contact Dr. Lindsay Olive. (LO)

UNIVERSITY SENATE: Dr. A. J. Bernatowicz, Associate Professor of Science, is the new Chairman of the Executive Committee of the University (of Hawaii) Senate.

RESEARCH VISITORS: Dr. Frederick K. Sparrow, Professor of Botany, University of Michigan, Ann Arbor, Michigan, has been provided research quarters this semester at the Department of Botany, University of Hawaii. Dr. Sparrow is doing research on the genus Physoderma, as yet not reported from Hawaii. He is making field studies and examining herbarium specimens at the Bernice P. Bishop Museum. He received his B. S. from the University of Michigan and his M. A. and Ph. D. from Harvard University. He was an Austin Fellow in 1927-29, and on the faculty of Radcliffe College (1927) and Dartmouth College (1929-36). He has been at the University of Michigan since 1936. From 1926-30 he was also with the Cold Spring Harbor Biological Station, Carnegie Institution; a National Research Council Fellow at Cornell in 1931 and at Cambridge and Copenhagen in 1932-33; a Research Fellow at the Oceanographic Institute, Woods Hole, 1934-36; Research Associate, Experiment Station, Michigan State College, 1943-46; Collaborator, Bureau of Plant Industry, USDA, 1943-46; and Researcher, Harvard-Atkins Gardens Research Laboratory in Cuba, 1949. He has been a member of the Committee of Biology and Agriculture, National Research Council, since 1953 and an active member of the Mycological Society (Secretary-Treasurer, 1945-47; Vice President, 1948; and President, 1949). His field of specialization is aquatic fungi, especially those which are parasites of aquatic plants and animals.

Dr. F. Raymond Fosberg and Dr. Marie-Helene Sachet of the Pacific Vegetation Project, National Research Council, spent a week in Hawaii after several weeks in Guam and Wake. Also on the trip was Robert Alexander of the Office of Naval Research who was here for four days. Dr. Fosberg examined Hawaiian and Pacific specimens of Malvaceae and Rubiaceae at the Bernice P. Bishop Museum Herbarium. He is preparing a monograph on the Hawaiian Psychotria. He also visited the island of Maui while here. Dr. Sachet studied Marquesan literature at the Museum's library and visited Maui and Kauai. (AKC)

PLANT QUARANTINE DIVISION, U.S.D.A.: H Ivan Rainwater, Inspector in Charge, Honolulu, departs soon for Washington, D. C., where he will be Assistant Staff Officer, Methods & Procedures, at the Division's headquarters. William R. Pifer, Supervisory Inspector, will also leave for Washington for an assignment at the Plant Inspection Station. Charles D. Nigro, Supervisory Inspector, was transferred to New York, and Gerald R. Solomon, Supervisory Inspector, was assigned as Inspector in Charge, Eagle Pass, Texas. Promoted to Supervisory Inspector was Harry T. Kumabe. (AKC)

BOTANICAL FORAY: Suggestions were made at the March Society Meeting on places to conduct a botanical trip during the summer. Dryland areas were Kaena Point, Pohakea Pass, Puu Kaua, and Puu Kaneoha; intermediate area, Kipapa Gulch; wetland areas, Castle Trail, Makua Valley, Pupukea, and Kaepaupau Valley. The committee, consisting of Miss Beatrice Krauss, chairman, Dr. Otto Degener, and Mr."W" Jan Newhouse, will further evaluate the above sites and recommend an appropriate one to the Executive Committee. (BK, TM & AKC)

NEW MEMBERS: The following names, recommended by the Membership Committee, were elected to membership at the March meeting: Dr. Elizabeth Mackay, Department of Home Economics, and Dr. Paul J. Scheuer, Department of Chemistry, University of Hawaii, Honolulu. (TM & AKC)

NATIONAL SOCIETIES: New officers for Biological Abstracts, a cooperative abstracting and indexing service, are Dr. Oswald Tippo, president; Dr. William C. Steere, vice president; Dr. Raymond L. Zwemer, treasurer; and Dr. Hiram T. Evans, secretary. Named to the Executive Committee are Dr. John T. Bonner and Dr. John M. Fogg, Jr.

Officers this year of the American Society of Plant Taxonomists are Dr. Ira L. Wiggins (Stanford University), president; Dr. Arthur Cronquist (New York Botanical Garden), council member; Dr. Charles H. Heiser, Jr. (Indiana University), council chairman; Dr. Lawrence R. Heckard (University of California), secretary; Dr. Richard W. Pohl (Iowa State University), treasurer; Dr. Peter H. Raven (Stanford University), editor-in-chief, Brittonia; Dr. H. W. Rickett (New York Botanical Garden), managing editor, Brittonia; and Dr. Reed C. Rollins (Gray Herbarium), AIBS Governing Board representative. (From AIBS Newsletter 4(1): 3).

SIXTH HAWAIIAN SCIENCE FAIR: The winners of the Hawaiian Botanical Society awards at the Sixth Hawaiian Science Fair were Elizabeth Nose, a senior student of Taduyuki Kato at Kauai High School, Lihue, Kauai, and Lynn Hirashima, an eighth grader at Kealahou School, Kealahou, Maui.

Miss Nose's exhibit was entitled "Culturing moss protonema." Her project was the culmination of three years' research work on the general subject. She has chosen to purchase an aquarium aerator and slide rule with the "wish award" money presented to her. Miss Hirashima's project was entitled "How can we prolong the freshness of carnations?" Judges for the Society were Dr. Albert J. Bernatowicz of the University of Hawaii (chairman) and E. H. Bryan, Jr., of the Bernice P. Bishop Museum.

The top winner of the fair was Ross Mobley of Kaimuki High School. His project was begun last summer while he was a junior apprentice at the University of Hawaii. He worked in the Department of Plant Pathology under Minoru Aragaki. His project was entitled, "The influence of papaya fruit constitutents on sporangial production of *Phytophthora parasitica* Dast." (MG)

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The HAWAIIAN BOTANICAL SOCIETY was founded in 1924 to "advance the science of Botany in all its applications, encourage research in Botany in all its phases," and "promote the welfare of its members and to develop the spirit of good fellowship and cooperation among them." "Any person interested in the plant life of the Hawaiian Islands is eligible for membership in this Society."

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The Hawaiian Botanical Society Newsletter is published monthly, except during the summer months of July, August, and September. It is distributed to all Society members and other interested individuals and institutions, with the purpose of informing them about botanical news and progress in Hawaii and the Pacific. News contributions and articles are welcomed. The deadline for submission of news items is the 20th of each month prior to publication.

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